GENETIC VARIATION AMONG NON-OIL SUNFLOWER CULTIVARS RELATED TO WATER DEFICIT STRESS TOLERANCE*

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ABSTRACT

Water deficit stress is one of the most prominent factors that limits yield of many crops in the world. This will hold true under rain fed and irrigated agriculture. This research targeted identification of the plant traits that are more related to water deficit tolerance. Three non-oil sunflower (*Helianthus annuus L.*) cultivars were compared; shumoos , select 1, and select 2. Seed of the cultivars were planted on the farm of Field Crops Station of the College of Agric., University of Baghdad in 2013.Three irrigation levels of water were used ; 320, 400, and 560 mm/season. A randomized complete block design of four replications in a factorial arrangement was used. When cultivars compared, select 2 gave higher number of seeds (1366/capitulum), 21.2 cm capitulum diameter, 99.7 days to physiological maturity, higher seed yield (144g/plant) and high seed weight (119.2mg/seed). Crop growth rate of cultivar was increased with increased level of irrigation water. At 320 mm, crop growth rate was 5.5 g/plant/day, increased to 7.1 g/plant/day at 560 mm/season. Seed filling period and plant height had higher ratio of genetic to environmental variance than other traits. Chlorophyll index, percent water loss (PWL) and days to 90% flowering had higher ratio of genetic to environmental variance than the rest of other studied traits. These five traits had at least 76% h^2b.s, and they were similar in P.C.V% and G.C.V%, so, they were recommended to be used as parameters to select sunflower genotypes tolerant to water deficit stress studies in a specific geographic area. Meanwhile, genotypic resultant values were coincided with many traits detected for drought stress tolerance by genetic to environment variance ratio.

Keywords: PWC, PWL, TDM, irrigation levels, h^2b%. and genetic variance
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التغاير الوراثي بين اصناف لا زيتية من زهرة الشمس مرتبطة بتحمل شد عجز الماء

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الملخص

ان شد عجز الماء من بين اهم العوامل البارزة في الحد من حاصلات المحاصيل في العالم. ان ذلك يصح على الزراعة الاروائية والديمية. كان هدف هذا البحث تشخيص صفات نباتية ذات علاقة اكثر بتحمل شد عجز الماء. قورنت ثلاثه اصناف زهرة شمس لا زيتية هي شموس ومنتخب 1 و منتخب 2. طبقت التجربة في حقل قسم المحاصيل الحقلية / كلية الزراعة / جامعة بغداد في 2013. استخدمت في البحث ثلاثه مستويات ري, 320 و 400 و 560 ملم في الموسم. طبقت تجربة عاملية بتصميم القوالب الكاملة المعشاة باربعة مكررات. اعطى الصنف منتخب 2 اعلى عدد بذور (1366 للقرص) و 21.2 سم لقطر القرص, ومعدل 99.7 يوما للنضج الفسلجي, واعلى حاصل بذور(144 غم للنبات), ووزن 119.2 ملغم للبذرة. ازداد معدل نمو النبات مع زيادة كمية الري, اذ كان المعدل 5.5 غم للنبات في اليوم في مستوى الري الاول وازداد الى 7.1 في المستوى الثالث. اعطت مده امتلاء البذور وارتفاع النبات اعلى نسبة تغاير وراثي الى بيئي, وجاءت بعدهما دليل الكلوروفيل ونسبة فقد الماء وايام 90% تزهير. امتلكت هذه الصفات الخمس نسبة توريث بالمعنى الواسع 76% فاكثر, وتماثلت فيها قيم P.C.V% مع G.C.V% , وبهذا تمت التوصية باستخدامها معايير لتحمل شد عجز الماء في دراسات مستقبلية لهذا المحصول. كانت في نفس الوقت قيم المحصلة الوراثية متطابقة مع الصفات المقترحة لتحمل شد عجز الماء عن طريق نسبة التغاير الوراثي الى البيئي.

1-INTRODUCTION

Abiotic stresses are major constraints to crop productivity and production in the world agriculture. Water stress deficit has the priority of importance among other abiotic stresses. Crop management practices and plant breeding practices almost share 50% each in crop productivity. Surface water on earth and ground water are being used in international agriculture beside rain-fed agriculture. Statistics of the FAO (11) indicated that about 15% of irrigated agriculture in the world produces an average of 35% of total crop production, and that the irrigated area is about 263 million hectares out of 1753 million hectares planted area in the world. Jury and Vaux (12) estimated that about 97.4% of water on earth is in the oceans and seas, 2% snow in the poles, the rest of that is 0.6% of total water is available for human use. On the other hand, Rockstrom et al. (21) reported that the annual amount of water required per capita to produce food is about 1200 cubic meter.

Different crops are different in their seasonal water requirements. Meanwhile, soil texture, temperature, wind velocity and some other biotic and abiotic variables affect crop requirements in a geographic area. Sunflower cultivars, oil and non-oil could be different in their seasonal water requirements according to their difference in plant height, leaf area, root size and plant seed yield. Elsahookie (9) reported that sunflower seasonal water requirement is between 500-600 mm.

Growth stages of crop plants in general, differ in their water requirements. Kirda et al.(14) reported that crop plants subjected to water stress at early stage did not decrease yield significantly as compared to that at flowering to physiologic maturity.

Water stress deficit opposed on the plants causes dramatic changes in plant morphology, physiology and productivity. These changes are due to changes on molecular level of crop, and it should be relative to the degree of that water deficit stress (8). However, these changes occur in degrees related to genes of crop exist in that environment. The objectives of this research were to identify some agronomic and physiologic traits of three non-oil sunflower cultivars related to water deficit stress tolerance, and the relative seed yield reduction related to irrigation water levels, and to determine genetic variance and broad sense heritabilities of traits studied.

This was applied in Abu-Ghraib city as a representative area of the middle region of Iraq. The three non-oil cultivars were, shumoos (the original population), select 1 and select 2 derived from the original population in a previous selection program. Traits as indicators to water deficit stress tolerance will be very helpful to screen genotypes of sunflower as drought tolerant in perspective sunflower breeding programs.

2- MATERIALS AND METHODS:

Field Experiment:

On a silt clay loam soil of the Field Crops Farm of the College of Agric., Univ. of Baghdad, an experiment was conducted including three non-oil sunflower cultivars, shumoos, select 1, and select 2. Three irrigation levels, 320 (I1), 400 (I2), and 560 mm (I3) were applied in a factorial experiment with RCBD of four replicates. The land was plowed, leveled and divided into plots of 3x2.6m. Fertilizers of 200 Kg N/ha of urea was added to the soil into two doses, first before planting, and the second when plants were about 50 cm high. The phosphate fertilizer 200 Kg of P_2O_5 was added before planting. Seeds were planted in rows 65 cm apart and 30 cm between plants in the first week of Feb. 2013, three seeds were planted in each hill, then when seedlings were about 10 cm high thinned to one. Weeding was done as needed.

To control irrigation level, plastic tanks were installed near the plots. Depth of each irrigation was fixed as 8 cm (17). The plot area was 7.8 m^2, and according to the depth of each irrigation (80 mm), a total of 624 liters of water was added in each irrigation. Treatments of I1, I2and I3 had 4, 5 and 7 irrigations along the growth season of the crop , respectively.

At physiologic maturity, measurements were taken on chlorophyll index by using Spad, plant leaf area, days to physiologic maturity and other traits as shown in Tables were recorded on five plants of each experimental unit.

Laboratory Tests:

To measure relative water content (RWC) of leaves, a five cm^2 of the middle of upper leaf was taken, weighed as fresh weight (FW1). Samples were left in room temperature for five hours then weighed (FW2), then soaked in distilled water and kept under refrigeration for 24 hrs., cleaned from water, then weighed as turged weight (TW). Samples were dried in oven for 48 hr at 80 C, then weighed as dry weight (DW) (16).

Calculations:

RWC= FW1 – DW / TW-DW (Mata and Lamattina, 16)

Percent of water loss (PWL) = (FW1 – FW2) (FW1 – DW) x 100

Relative water loss (RWL) = FW1 – FW2 /DW

Specific leaf area (SPL) = leaf area / DW

Leaf area / plant = 0.65 x $\sum wi^2$ (Elsahookie and Eldabas, 3)

Relative dry weight (RDW) of each leaf was calculated as follows: RDW=TW-DW/DW (Ali et al,1). Seed growth rate (SGR) was calculated by dividing seed weight by days from planting to physiologic maturity. Crop growth rate was calculated by drying 5 plants air dry) then divide plant dry weight by days from planting to physiologic maturity. Genotypic resultant (GR) was determind according to the formula:

GR= stability %x $\frac{\text{cultivar mean}}{\textit{mean of all cultivars}}$ (Elsahookie, 4).

Stability=1-C.V

Genetic coefficient variation (GCV), phenotypic coefficient of variation (PCV), broad sence heritability, genetic and phenotypic variances were calculated as:

σ^2 e = MSe

σ^2 g = MSg – Mse/ d.f

σ^2 p = σ^2 g $^+$ σ^2 e (Singh & Chaudhary, 22)

3- RESULTS AND DISCUSSION

Days to 90% flowering and physiologic maturity:

There were significant differences in days to 90% flowering due to irrigation water levels, and the values were 80.9, 81.1 and 82.0 days for I1, I2 and I3, respectively . Cultivars were also significantly different, shumoos, select 1 and select2 gave 79.0, 81.7 and 82.9 days, respectively However, the interaction of cultivar x water levels was not significant. This explains that cultivars were reacted similarly to water levels. Days to 90% physiologic maturity were influenced by cultivars only, irrigation water levels did not show significant difference in this trait, neither the interaction was a significant. shumoos, select1 and select2 matured after 100.9, 99.8 and 99.7 days, respectively (data not shown).

Plant height, leaf area and chlorophyll:

The non-oil sunflower cultivars are higher in plant height as compared to oil cultivars. shumoos, select 1 and select 2 had 247, 259 and 241 cm, respectively. Irrigation levels, I1, I2 and I3 gave 241, 250 and 261 cm plant height with a significant difference between every two of them. The interaction of cultivars x irrigation levels was significant. The highert value was 266 cm for select 1 at I3, and the lowert was 234 cm with select 2 at I1. Shumoos did not respond to irrigation water in plant height like other two cultivars. Water stress at I1 has decreased plant height of all the three cultivars studied. This could be attributed to low cell division of plant tissues. This result is with agreement with those of some researchers (2, 18, 19). Significant differences were detected in leaf area (m^2/plant) among irrigation treatments. The treatments I1, I2 and I3 gave 0.84, 0.87, 1.02 m^2/plant leaf area, respectively. However, cultivars did not show any significant difference in this trait, they were 0.86, 0.90 and 0.97 m^2/plant, respectively. Meanwhile, the interaction was significant, since shumoos gave 0.82 m^2/plant at each irrigation levels of I1 and I2. Differences in leaf area of plants grown under I1 and I2 were not significant as compared to

differences between I2 and I3. Select 2 had the largest leaf area (1.15 m^2/plant) at I3. Chlorophyll index determined by Spad showed that irrigation levels had significant effect in reducing this value in plant leaves. Treatments of I1, I2 and I3 had 33.4, 35.6 and

39.3 values respectively. Cultivars responded similarly to water levels as indicated by the non-significant interaction. However, select 2 showed the higher value of chlorophyll index (37.2) while the lower was with the original cultivar (shumoos) which gave 35.0. Levitt (15) reported that water stress results in stomata closure, that leads to low growth of plastids, while Karron and Maranvilla (13) reported that low water causes less nitrogen uptake, and then, chlorophyll will be less.

Water and dry weight of leaves: Relative water contents (RWC) in plants leaves were significantly influenced by cultivars, irrigation levels, and their interaction (Table 1)

Table 1. Relative water content and relative dry weight of leaves gram water /gram dry weight after 24 hrs. of water soaking (RDW). (Higher values for RWC). I1, I2 and I3 were 320,400 and 560 mm/season, respectively.

	Irrigation levels			
Cultivars	I1	I2	I3	Mean
Shumoos	0.81	0.83	0.85	0.83
	6.5	6.7	7.6	6.9
Select 1	0.81	0.83	0.90	0.85
	4.7	6.6	8.5	6.6
Select 2	0.85	0.87	0.89	0.87
	6.1	7.3	8.4	7.3
lsd 5%	0.02			0.01
	ns			ns
Means	0.82	0.84	0.88	
	5.8	6.9	8.2	
lsd 5%	0.01			
	0.8			

The data showed that select 2 had higher value of RWC than other two cultivars, also, I3 had higher value, and the most stable cultivar across irrigation levels was select 2, as compared to select 1, that increased from 0.81 to 0.90 across irrigation levels, indicating that select 2 was more stable in RWC than other cultivars. Values of RDW were significant for irrigation levels only (Table 1). This indicates that this trait is not recommended to detect water deficit stress tolerance. All three cultivars responded similarly to irrigation water, increasing value of RDW with increasing irrigation water. This could be due to better growth of leaves under sufficient water, then the stomata will be more in number and size, so, the leaves absorb more water when soaked.

Specific leaf area (SLA) of cultivars under irrigation levels:

Table 2. Ratio of leaf area (cm^2) to each gram dry weight (SLA) of sunflower cultivars as influenced by irrigation levels.

	Irrigation levels			
Cultivars	I1	I2	I3	Mean
Shumoos	102.7	113.3	120.2	112.1
Select 1	105.0	108.5	131.9	115.5
Select 2	103.9	107.3	118.1	109.8
lsd 5%	4.5			2.6
Means	104.2	109.7	123.4	
lsd 5%	2.6			

Each gram of dry leaf area was giving higher area as irrigation level increased form I1, I2 to I3. This explains that enough water causes leaf area to expand more. Cultivars responded differently in this trait, since some of them responded less or more than others. Select 2 gave lower SLA, this implies that this cultivar had thicker leaves than other two cultivars. We can conclude that sunflower cultivars of thicker leaves could be better in water deficit stress tolerance.

Water losses from detached leaves:
Two tests were applied under this title, percent of water lost to leaf water (PWL), and relative water loss (RWL) which represents ratio of water lost/dry weight (Table 3).

Table3. Values of PWL (upper numbers) and RWL of sunflower cultivars grown under three irrigation levels.

	Irrigation levels			
Cultivars	I1	I2	I3	Means
Shumoos	75.4	65.3	61.8	67.5
	4.9	3.3	2.4	3.5
Select 1	67.8	64.5	55.5	62.6
	6.3	4.9	4.0	5.1
Select 2	76.2	67.4	64.9	69.5
	7.0	6.2	5.7	6.3
lsd 5%	2.8			1.6
	ns			0.4
Means	73.1	65.7	60.7	
	6.0	4.8	4.0	
lsd 5%	1.6			
	0.4			

Percentages of leaf water (PWL) of cultivars were significantly different. Select 2 had the higher loss percentage, and select 1, the lower. Increased irrigation water decreased this value. There was a drastic significant decrease in this trait in select 1, when moved from I2 to I3 irrigation levels, and this caused the significant interaction. Irrigation levels had 73.1, 65.7, and 60.7 percent of water loss for I1, I2 and I3, respectively.
This test was applied in room temperature (without sunlight) so, if it has been done in open door environment, stomata closure could explain this trait better.
Values of RWL (Table 3) show that select 2 had higher value as compared to the other two cultivars, and this is in agreement with values of PWL of same cultivars. However irrigation water from I1 to I3 deceased value from 6.0 to 4.0. The interaction was not significant, indicating a similar response of cultivars to water levels in this trait.

Days of seed filling and seed growth rate:
Elsahookie (6) showed that days to seed filling, seed growth rate and seed weight are intercorrelated. Days of seed filling of sunflowers cultivars were significantly different, and reduced irrigation water levels have reduced days of seed filling. In general, days of seed filling could be related to plant growth rate and seed growth rate (Table 4). Shumoos had the longer time (19.8 day) from flowering to maturity, while select 2 had the shorter (17.1 day). Cultivars x irrigation levels interaction was not significant (Table 4). Seed growth rate was in the same rhythm with days to maturity. Cultivars were significantly different, but, select 2 had higher seed growth rate (8.2), while shumoos had the lower value (6.6) explaining why this cultivar elapsed longer time for seed filling. Seed growth rate was reduced with reduced irrigation level; I1 gave 7.0 mg/d increased to 7.9 mg/d for I3. However, the interaction was not significant indicating that cultivars responded the same to reduced irrigation levels in both days to maturity and seed growth rate.

Table 4. Days of seed filling (upper value) and seed growth rate (mg/ seed/ d) of sunflower cultivars under three irrigation levels.

	Irrigation levels			
Cultivars	I1	I2	I3	Means
Shumoos	18.8	20.0	20.8	19.8
	6.2	6.6	7.1	6.6
Select 1	16.5	17.5	18.5	17.5
	7.2	7.5	7.9	7.5
Select 2	15.8	17.3	18.3	17.1
	7.8	8.2	8.5	8.2
lsd 5%	ns			0.4
	ns			0.2
Means	17.0	18.3	19.2	
	7.0	7.4	7.9	
lsd 5%	0.4			
	0.2			

Plant growth rate (g/day) and plant dry weight (g):

In general, if growth variables were enough, plant seed yield will be proportional to its dry weight through season if harvest index of genotype did not play an important role. Cultivars were significantly different in plant dry weight, select 1 had the lower value (552g), and select 2 had 679g. Reduced irrigation levels reduced plant dry weight very remarkably (Table 5).

Table 5. Plant growth rate (g/d) and plant dry weight (g) of sunflower cultivars grown under irrigation levels.

	Irrigation levels			
Cultivars	I1	I2	I3	Means
Shumoos	5.3 525	6.0 603	7.5 757	6.2 628
Select 1	4.8 476	5.5 564	6.2 615	5.5 552
Select 2	6.3 607	6.9 681	7.5 750	6.9 679
lsd 5%	ns			0.4 53
Means	5.5 536	6.1 616	7.1 707	
lsd 5%	0.4 53			

Higher values of plant dry weight were increased as water level was increased. The low irrigation level I1 gave 536 g/plant, while I3 gave 707 g/plant. The three cultivars responded similarly to water levels in both plant dry weight and plant growth rate. Thus, there was no significant interaction. Plant dry weights of cultivars were proportional to plant growth rates. The high cultivar in plant growth rate was select 2, while the lower was select 1. Plant growth rates were increased from 5.5 g/plant/d at I1 to 7.1 g/plant/d at I3. Plant growth rate linearly responded to increascd irrigation water.

Yield components:

Number of seeds per head or per plant in all seed crops has the most effective part in seed yield, since this number is established at early growth stage of plant life, since the system capacity constant in the plant is close to be in its maximum (5).

Table 6. Plant seed number, seed weight (mg), and seed yield (g/plant) of sunflower cultivars grown under three irrigation levels.

	Irrigation levels			
Cultivars	I1	I2	I3	Means
Shumoos	1201 101 125	1274 109 130	1309 119 136	1261 110 130
Select 1	1221 112 127	1345 115 131	1430 125 147	1332 117 135
Select 2	1257 113 142	1358 118 144	1483 127 147	1366 119 144
Lsd 5%	56 6 2			32 11 1
Means	1226 108 131	1235 114 135	1407 124 143	
lsd 5%	32 ns 1			

Seed number per plant was significantly increased as irrigation water was increased (Table 6). Shumoos had lower number while select 2 had the higher (1366). Cultivars reacted differently in plant seed number to irrigation levels. Shumoos reacted less, while select 2 reacted higher. Although number of seeds per plant is positively correlated with capitulum area, but the differences in this trait was negligible, since, capitulum diameters of cultivars were between 20 to 21 cm (data no shown).

The least influenced trait by irrigation water was seed weight. There was an increase in seed weight as irrigation water increased, but differences were not significant. However, cultivars reacted differently to irrigation water in seed weight as the interaction indicates. Differences in cultivars seed

Weights were significant, but they were not so different. Plant seed yield is a result of seed number and seed weight, and it was significantly influenced by irrigation levels, cultivars, and their interaction. Treatment of I1 gave 131 g seed /plant , while I3 gave 143 g seed /plant. Select 2 had stable values across irrigation levels, indicating its genetic superiority to the other two cultivars. This could be attributed to the high fertility % of select 2 (88%) as compared to the other cultivars. Bulk density of seed is also related to seed yield. However, bulk density ranged from 0.27 to 0.28 across irrigation levels and cultivars (data not shown).

Genetic and environmental variances and heritability:

Stability of cultivars performance across environmental variables is an indication of its genetic ability to tolerate those biotic or abiotic variables. Determination of some genetic traits related to water deficit tolerance is helpful in selection programs to breed crop cultivar tolerant to this stress. To know that, plant genetic variance should be calculated. Elsahookie et al.(10) found that genetic resultant was a good test to judge the tolerance of some oat cultivars to drought stress. They found that total dry matter of cultivar plant and its plant growth rate were among the best traits related to drought tolerance. Robinowicz et al (20) reported that one of the important things happens in plant growth under drought stress is DNA-methylation. This methylation was increased in plants as drought stress increased. DNA-methylation affects the amount of mRNA, and that affect gene silencing. Plant traits differ in their genetic variance and the ratio of genetic to environmental variances. Table 7 shows the values obtained on the plants of sunflower cultivars grown under irrigation levels 320, 400 and 560 mm water/season

We can notice in Table 7 that days to seed filling had the higher ratio of genetic to environment variance. So, this trait could be taken as the best trait in the cultivar to be an indication to water deficit stress tolerance. This trait had the higher value of broad senes heritability (89%) among all other traits studied. Some other traits come in the next order of importance are, plant height, chlorophyll index, PWL and days to 90% flowering. Plant height, chlorophyll index, PWL, and days to 90% flowering had h^2b.s % of 81.27, 78.3%, 77.5% and 76.9%, respectively. Higher ratio of genetic to environment variance, coincided with higher heritability, along with intense selection will be very helpful to breed for drought stress tolerance. In general, traits been mentioned and recommended for selection to breed for drought stress tolerance almost had equal variances of at GCV % and PCV %, while other traits were very different. Drought stress causes several changes in plant performance for many changes take place in the plant due to drought stress, such as; degragation of some proteins, increased production of ROS, and several other signaling in metabolism. (8).

Genotypic resultants of sunflower cultivars:

Differences in genotypic resultant of traits of cultivars studied under three levels of irrigation water are shown in Table 8.

Table 8. Values of GR % of some traits of sunflower cultivars.

Table 7. Components of genetic and environmental variance, PCV%, GCV% and h2b.s of traits studied on non-oil sunflower cultivars grown under 320, 400 and 560 mm season/water

Trait	σ2 g	σ2 e	σ2 g/ σ2 e	PCV%	GCV%	h^2b.s%
Days to 90% flowering	3.904	1.176	3.32	2.776	2.434	76.8
Days to 90% phys. Maturity	0.394	0.801	0.492	1.092	0.627	33.0
Plant height	52.749	12.17	4.33	3.21	2.90	81.3
Plant leaf area	0.001	0.002	0.398	6.64	3.59	28.5
Chlor. units	2.235	0.618	3.617	4.678	4.140	78.3
RWC	0.00001	0.0004	2.837	2.70	2.32	73.9
RDW	0.173	0.042	0.242	6.728	2.976	19.5
SLA	0.065	2.86	0.023	1.520	0.227	2.2
PWL	3.610	12.42	3.440	6.02	5.30	77.5
RWL	1.822	1.015	1.794	33.96	27.27	64.2
Days of seed filling	2.174	0.269	8.098	8.616	8.13	89.0
Dry weight	3342.25	9523	0.351	18.294	9.33	26.0
Plant growth rate	0.263	0.434	1.65	13.4	10.6	62.3
Seed/plant	1476.0	2710	1.84	4.90	3.94	65.0
Seed yield	72.790	29.67	0.407	7.53	4.05	29.0
Seed weight	0.727	53.01	0.014	6.35	0.734	1.0

Trait	shumoos	select 1	select 2
Days to 90% flowering	98.0	98.9	101.0
Plant height	98.3	103.1	94.1
Plant leaf are	81.0	89.0	77.3
RWC	95.5	95.3	99.9
PWL	92.2	85.3	96.4
RDW	88.7	67.4	93.4
RWL	48.6	83.6	113.4
Day of seed filling	104.2	88.5	88.0
Chlor. units	87.3	91.9	95.4
Plant seed no.	93.0	88.6	98.6
Seed yield	91.7	92.3	96.9
Seed weight	86.8	93.1	94.5

As we have seen before in Table 6, select 2 had the higher value of plant seed yield across the three levels of irrigation water (144 g/plant). This cultivar as shown in Table 8, has higher value of GR% for several traits, days to 90% flowering, RWC, PWL, RWL and crop growth rate, 101, 99.9, 96.4, 93.4 and 101.6, respectively. Other traits gave lower values of GR cannot be used for selection. According to similarities of traits recommended for selecting sunflower plants more tolerant to drought stress, by using ratio of genetic to environmental variance, and the use of GR%, the later could be recommended for its easier calculation. However, Elsahookie and

Al-Rawi (7) have reported their recommendation to use GR% as compared to other stability equations.

REFERENCES:

[1] Ali, M.A., A. Abbas, S. Niaz, M. Zulkiffal, and S. Ali. 2009. Morpho-physiological criteria for drought tolerance in sorgum (*Sorghum bicolor*) at seedling and post-anthesis stage. Int. J. Agric. Biol. 11 (6): 647-680.

[2] Bajehbaj, A. A. 2010. The effect of water deficit on characteristics physiological chemical of sunflower (*Heliauthus annuus L.*) variance. Adv. Environ. Biol. J. 4(1): 24-30.

[3] Elsahookie, M. M. and E. E. Eldabas. 1982. One leaf daimension to estimate leaf area in sunflower. J. Agron. and Crop Sci. 151 (6): 621-621.

[4] Elsahookie, M. M. 1996. Applications on stability analysis of genotypes. TIJAS, 27 (2): 11-20.

[5] Elsahookie, M. M. 2007. Dimensions of SCC theory in maize hybrid – inbred comparison. TIJAS, 38 (1): 128 -137.

[6] Elsahookie, M. M. 2009. Seed Growth Relationships. Dept. of field Crops, Coll. of Agric., Univ. of Baghdad. P. 52 – 57.

[7] Elsahookie, M. M. and O.H.Al-Rawi.2011.Effeciency of some equations to analyze genotypex environment interactions.TIJAS,42(6):1-18.

[8] Elsahookie, M. M. 2013a. Breeding Crops for Abiotic Stress – A Molecular Approach and Epigenetics. Dept. of Field Crop Sci., Coll. of Agric., Univ, of Baghdad. Pp. 224.

[9] Elsahookie, M. M. 2013b. Environmental Data Concern Crop Productivity in Baghdad. Dept. of Field Crops, Coll. of Agric., Univ. of Baghdad.pp.13.

[10] Elsahookie, M. M., N. Younis, and M. Al-Khafajy. 2013. Performance, variance components and heritability of oats cultivars under irrigation intervals. TIJAS, 44(1): 1 – 15.

[11] FAOSTAT. 2000. FAO Statistical Database. Food and Agric. Organization of the United Nations. http://apps.fao.org.

[12] Jury, W.A., and H.J. Vaux. 2007. The emerging global water crisis: Managing scarcity and conflict between water users. Adv. Agron., 95: 1-76.

[13] Karron, M.G., and J.H. Maranville. 1994. Response of wheat cultivars to different soil nitrogen and moisture regime. I. Dry matter partitioning and root growth. J. Plant Nutri. 17 (5): 729 –744.

[14] Kirda, C., R. Kanber, and K. Tulucu. 1996. Yield response of cotton, maize, soybean, sugerbeet, sunflower and wheat to deficit irrigation. In nuclear techniques to assess irrigation schedules for field crops. IAEA. TECDOC. 888: 131-138.

[15] Levitt, J. 1980. Response of Plant Environmental of Stress. Acad. Press, New york, USA, p.33.

[16] Mata, C., and L. Lamattina. 2001. Nitric oxide induces stomatal closure and enhances the adaptive plant responses against drought stress. Plant Physiol., 126:1196-1204.

[17] Mavi, H.S., and G. J. Tupper. 2004. Agrometeorology Principles and Applications of Climate Studies in Agriculture. Food Products Press. Binghampton, USA, pp.364.

[18] Mojaddam, M., S. Lack, and A. Shakuhfar. 2011. Effects of water stress and different levels of nitrogen on yield, yield components and water use efficiency of sunflower hybrid euroflor. Environmental Biol., 5:3410 – 3417.

[19] Oraki, H., F. P. Khajani, and M. A. Khana. 2012. Effect of water deficit stress on proline content, soluble sugars, chlorophyll and grain yield of sunflower (*Helianthus annuus L.*) hybrids. Afri. J. Biotech., 11: 164-168.

[20] Robinowicz, p., R. Citek, M. Budiman, A. Numberg, J. Bedell, N. Lakey, A. Oshaughnessy, L. Nascimenta, W. McCombie, and R. Martienssen. 2005. Differential methylation of genes and repeats in land plants. Genome Res. 15: 1431 – 1440.

[21] Rockstrom, J., L. Gordon, M. Falkenmark, C. Folke, and M. Engvall. 1999. Linkages among water vapor flows, food production, and terrestrial ecosystems services. Conserve Ecol., 3: 1-28.

[22] Singh, R. K., and B. D. Chaudhary. 1989. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publ., New Delhi, pp.318